HUC 07120001030050

HARZA Consulting Engineers and Scientists

Property of
Lake and River Enhancement Section
Division of Fish and Wildlife/IDNR
402 W. Washington Street, W-273
Indianapolis, IN 46204

August 2, 1995

Mr. Dean A. Heise
La Porte Park and Recreation Department
250 Pine Lake Avenue
La Porte, Indiana 46350

Subject: Clear Lake Enhancement Project
Submittal of Alum Consultant's Report

Dear Dean:

I am pleased to submit the findings of Environmental Research and Design, Inc. (ERD) about the potential use of stormwater alum treatment at Clear Lake. This technology has been in use at water treatment plants for over a century and recently has been applied to lakes with tremendous success. ERD and Harza believe that, while many details remain to be investigated, stormwater alum treatment at Clear Lake will greatly enhance incoming water quality at Clear Lake. ERD's study indicates that this system will reduce the annual pollutant load to the lake from the Clay Street sewer by 80%. I have attached ERD's reports for your review and use, and below summarize their findings.

Background

Alum, or aluminum sulfate, $Al_2(SO_4)_3 \cdot 18H_2O$, was known to the early Egyptians of 2000 BC. Its use for water treatment was first mentioned by Pliny (ca. 77 AD) in describing the use of both lime and alum as useful for rendering bitter water potable[1]. The earliest use of alum in treating municipal water supplies occurred at Bolton, England in 1881. It has been in common use in the U.S. for treating public drinking water supplies for over 100 years.

In addition to clarifying water for drinking, alum has been used to remove phosphorus (P) from wastewater and to inactivate P in lake sediments. There are basically two methods for treating lakes with alum. The first, practiced for about three decades, is whole-lake treatments, where a barge systematically traverses the lake to mix liquid alum in it. In recent years, alum dosing systems to gradually treat inflowing waters have been developed and installed in urban lakes. Injection of alum into storm sewers has the potential for reducing water quality impacts of the stormwater pollutants on receiving lakes.

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1 J. M. Cohen and S. A. Hannah. Chapter 3, Coagulation and Flocculation, in Water Quality and Treatment: A Handbook of Public Water Supplies. Prepared by the American Water Works Association, Inc. Washington, DC. 1971.

Sears Tower 233 South Wacker Drive Chicago, Illinois 60606-6392
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How Does It Work?

Pollutants are removed from stormwater through formation of insoluble precipitates, by sorption onto the surface of flocs or polymers, and by occlusion and sedimentation of pollutants in these flocs[2]. When alum is added to water, it dissociates, forming aluminum ions that are immediately hydrated. A progressive series of hydrolysis reactions occurs, leading to the formation of aluminum hydroxide, a colloidal amorphous floc with high coagulation and P adsorption properties. The hydrolysis process is dependent on water pH and alkalinity. The floc grows in size and weight and settles out of suspension, dramatically increasing water clarity. In the application proposed at Clear Lake, the alum floc will settle in the rehabilitated sediment trap at the southwest corner of the lake.

Ecological Effects

Alum will enhance the removal of suspended solids from the stormwater entering Clear Lake. Additionally, alum will remove significant portions of the dissolved pollutant load. Alum has a particular affinity for dissolved P. The effects of this will be manifested in a long-term improvement in lake water clarity. Further, with improved water clarity, growth of aquatic macrophytes will improve, but with the City's continued weed harvesting, this should only be a temporary phenomenon. In the long term, reduced nutrient loadings from source control (alum treatment of influent) and internal recycling (plant harvest) will reduce organic productivity in Clear Lake.

Many laymen are concerned about the use of alum in natural systems. The aquatic nature and toxicity of the aluminum ions changes with time. Researchers currently believe that this is related to the physical size of the floc, with finer (i.e. colloidal) floc adhering to mucous on fish gill epithelia, causing asphyxiation or oxygen deprivation[3]. This does not occur with larger flocs. Therefore, current designs for stormwater alum dosing systems inject the alum sufficiently upstream of the receiving lake to allow for hydrolysis and polymerization to occur

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[2] G. D. Cooke and R. H. Kennedy. Precipitation and Inactivation of Phosphorus as a Lake Restoration Technique. EPA 600/3-81-012. US Environmental Protection Agency, Washington, DC. 1981.

[3] G. D. Cooke, E. B. Welch, S. A. Peterson, and P. R. Newroth. Lake and Reservoir Restoration (2nd Edition). Butterworth Publishers, Stoneham, MA 548 pp. 1993.

within the sewer system. When the treated stormwater actually reaches the lake, toxic effects are no longer likely.

Recommended System

ERD proposes a system to inject liquid alum into the stormwater flow from the Clay Street sewer upstream of Clear Lake (Attachment 1). A flow meter installed in the 48-inch storm sewer leading to Clear Lake will control an alum pump, to inject alum on a flow-proportioned basis. A small pre-fabricated building will house all equipment and the alum storage tank. ERD's recommended system includes pH monitoring of the lake, buffer system, a mixing device to improve coagulation, and floc sump.

ERD has provided Harza with a turn-key proposal for the alum stormwater treatment system (tabulated below). Their detailed proposal is Attachment 2. Given the large number of particulars that should be examined prior to design and installation of the system, we recommend that the City proceed with the preliminary design phase.

Phase	Person-hours	Salaries	Expenses	Total Cost
I. Preliminary Design	146	$9,860	$5,815	$15,675
II. Final Design	62	3,610	410	4,020
III. Fabrication, Installation & Start-up	176	11,920	68,850	80,770
IV. Operation	32	2,400	1,000	3,400
Total	416	$27,790	$76,075	$103,865

We also recommend a survey of fish, aquatic invertebrates and aquatic plants of Clear Lake. This survey would serve as a baseline for which any potential effects of the proposed alum system could be measured. The survey could also update the Lake Eutrophication Index for Clear Lake, last performed by Harza in 1989. A comprehensive survey of the lake would cost about $5,000. You may request the IDNR to perform this service at no cost to the City as part of their routine duties. They can probably provide the service, contingent upon their other priorities and scheduling constraints.

Very truly yours,

David

David B. Pott
Project Manager

Attachments: 1. ERD report dated July 7, 1995
2. ERD letter proposal dated June 28, 1995

cc: J. Ray, DNR (w/ attachments)

Attachment 1

ERD ENVIRONMENTAL RESEARCH & DESIGN, INC.

CLEAR LAKE
ALUM STORMWATER
TREATMENT EVALUATION

LaPorte, Indiana

Presented To:

David B. Pott
Harza Consulting Engineers and Scientists
Sears Tower
233 South Wacker Drive
Chicago, IL 60606-6392

June 1995

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ERD

ENVIRONMENTAL RESEARCH & DESIGN, INC.

WATER QUALITY ENGINEERING
3419 TRENTWOOD BOULEVARD ■ SUITE 101 ■ ORLANDO, FLORIDA 32812
TELEPHONE: (407) 855-9465 FAX: (407) 826-0419

June 7, 1995

Mr. David B. Pott
Harza Consulting Engineers and Scientists
Sears Tower
233 South Wacker Drive
Chicago, IL 60606-6392

RE: Clear Lake - LaPorte, IN/Alum Stormwater Treatment Evaluation

Dear Mr. Pott:

As you requested, Environmental Research & Design, Inc. (ERD) has conducted an evaluation of the feasibility of using alum for treatment of stormwater discharges prior to entering Clear Lake. This evaluation is based upon our experience with previous alum stormwater treatment systems which we have designed and constructed within the states of Florida and Washington, along with site-specific information provided by Harza for this area. A brief description of the theoretical basis for alum treatment of stormwater runoff and the specifics of a proposed alum stormwater treatment system for Clear Lake are given in the following sections.

Process Chemistry of Alum

Alum is an acid salt of aluminum that has been used for hundreds of years to treat drinking water, for phosphorus removal in the wastewater industry, and also in lake restoration projects for water column clarification and as a method of inactivating sediment release of phosphorus into the overlying water column during anaerobic conditions. However, the use of alum for treatment of stormwater runoff is relatively new.

Upon addition of liquid alum to stormwater, non-toxic precipitates of $Al(PO_4)$ and $Al(OH)_3$ form quickly. Aluminum hydroxide, $Al(OH)_3$, is a gelatinous floc that attracts and absorbs phosphorus, heavy metals, suspended solids and bacteria, causing them to rapidly settle from the water column leaving a clear treated water. The insoluble precipitates formed during this process are non-toxic and virtually inert. Alum treatment of stormwater runoff has been shown to consistently reduce concentrations of orthophosphorus and total phosphorus by 85-95%, heavy metals by 80-90%, suspended solids by 95%, total nitrogen by 50-80%, and coliform bacteria by more than 99%.

Operation of the alum stormwater treatment system at a dose of 10 mg/l resulted in significant improvements in water quality compared with pre-treatment characteristics. Water column concentrations of total nitrogen have been reduced by 78%, orthophosphorus by 91%, total phosphorus by 89%, BOD by 93%, and turbidity by 89%. Measured concentrations of all heavy metals have been extremely low within Lake Ella following alum treatment, with mean concentrations of cadmium and chromium less than 1 μg/l and mean concentrations of copper and lead less than 5 μg/l.

The second alum stormwater treatment system was constructed at Lake Dot in Orlando, Florida in 1989. This system was installed in conjunction with the Orlando Arena, the home of the NBA's Orlando Magic. Lake Dot is a small, 5.92-acre lake in downtown Orlando, adjacent to the new Orlando Arena, which receives untreated stormwater runoff from a highly urbanized watershed covering approximately 305 acres. More than 95% of all runoff inputs enter the lake through a single 108-inch stormsewer line. Before 1989, dense algal blooms were a constant occurrence, and periodic fish kills were observed.

The alum stormwater treatment system for Lake Dot uses sonic flow meters and variable speed injection pumps to simultaneously inject both liquid alum and sodium aluminate into the incoming stormsewer line on a flow-weighted basis before discharge to Lake Dot. Sodium aluminate is an alkaline aluminum salt that offsets reductions in pH, which may occur when using alum alone. By varying the ratio of alum and sodium aluminate added to the runoff flow, any desired final pH level can be achieved in the treated water.

Operation of the alum stormwater treatment system has substantially improved the water quality of Lake Dot. Concentrations of total phosphorus and orthophosphorus have been reduced in excess of 90%, chlorophyll-a and suspended solids have been reduced by 86%, and total nitrogen by 46%, while water column transparency increased by 200%. Concentrations of both total and dissolved aluminum are lower following alum treatment than before alum treatment. As a result of the alum treatment process, Lake Dot has returned to near-oligotrophic conditions with healthy populations of game fish and shoreline vegetation.

In addition to the Lake Ella and Lake Dot alum stormwater treatment systems, five additional systems have been placed into operation. These include Lake Lucerne in Orlando, FL; Lake Osceola in Winter Park, FL; Lake Cannon in Polk County, FL; Lake Sammamish in King County, WA; and Channel 2 in Pinellas Park, FL. ERD is presently designing alum stormwater treatment systems for Lake Maggiore in St. Petersburg, FL; Lake Tuscawilla in Ocala, FL; Lake Mizell in Winter Park, FL; Lake Virginia in Winter Park, FL; and Lake Holden in Orange County, FL.

Chemical Requirements

Based on information provided by Harza, the 88-acre watershed for the 48-inch outfall has a total annual runoff volume of approximately 194 ac-ft. For this analysis, it is assumed that the alum stormwater treatment system will treat 100% of the annual runoff volume generated. It is also assumed that treatment of runoff will require an alum dose of 15 mg/l as Al_2O_3. The actual dose necessary for treatment of stormwater discharges from this watershed will need to be determined during the preliminary design phase through extensive laboratory testing. Alum doses used on previous stormwater treatment systems have ranged from 10-20 mg/l as Al_2O_3.

Based on a dose of 15 mg/l as Al_2O_3, the annual alum volume necessary for treatment of 100% of the annual runoff flow is approximately 8,580 gallons, or approximately 4 tanker trucks containing 2,145 gallons each. To provide adequate chemical storage for the design storm event and to limit the frequency of alum deliveries, an on-site alum storage tank volume of 2,500 gallons was selected. This tank volume will allow a complete tanker delivery, with the storage tank containing more than 345 gallons. At a price of $0.52/gallon, annual alum costs for stormwater treatment within the 88-acre watershed will be approximately $4,462.

Floc Accumulation and Removal

Based on settling analyses completed for previous projects, the treatment of stormwater runoff from the 88-acre watershed will generate approximately 0.39 ac-ft of floc each year. Annual floc accumulation within the proposed sediment trap will be approximately 0.39 ft/yr, based on a bottom surface area of 1 acre. The floc accumulation is based upon a 30-day settling time. Over longer periods, floc consolidation continues to occur, and actual measured depths within the pond will probably be much less than these estimates. Floc removal within the settling basin will probably be necessary every 1-2 years. It appears at this time that the best option for floc removal from the sediment trap is to use a drying bed area at the same location or pump the floc into the sanitary sewer if acceptable to the City. For ease in removing alum floc, we recommend that an area approximately 40 ft in diameter and 10 ft deep be constructed in the bottom of the sediment trap, adjacent to the outfall pipe. A PVC pipe can be constructed several feet from the bottom of the 10 ft deep sump to the shoreline. The suction hose from a solids handling pump could be connected to the PVC pipe and the floc pumped to a solids drying area or sanitary sewer.

Capital Cost

A conceptual opinion of probable construction cost for the alum system is enclosed in the attached evaluation. The estimated cost for laboratory testing, design, and construction of the alum treatment system is $100,000. This cost does not include the cost of constructing the sediment trap or providing a power service or water service to the alum facility. The construction cost for the alum stormwater treatment system equates to $1,136 per acre of watershed area treated. This cost is extremely reasonable in comparison with other traditional stormwater management alternatives. In addition, no other stormwater management technique can provide comparable removal efficiencies.

Operation and Maintenance

Once in operation, the alum treatment system will require weekly visits by personnel to verify system operation and check the quantity of alum remaining in the tank. These weekly visits will require approximately 4 man-hours each week or 208 man-hours each year. Additional costs will be involved in removing and drying the alum floc or pumping it to the sanitary sewer, and incidental repairs and replacement of system components. In addition, routine water quality monitoring and benthic monitoring should be performed for at least the first several years. Annual operation and maintenance costs, including the cost of chemicals, is estimated to be approximately $9,522/year.

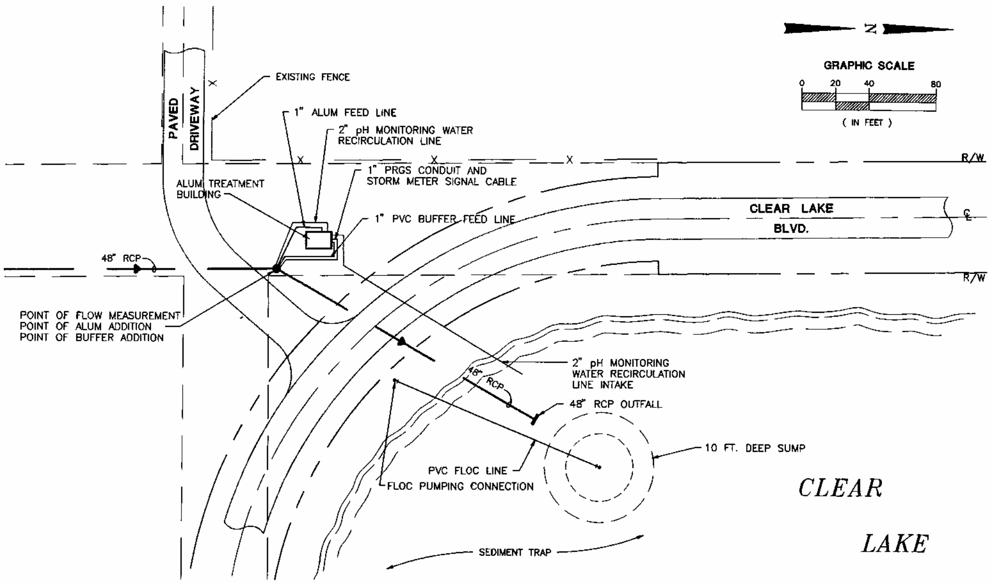
Additional field sample collection and laboratory testing, including stormwater sample collection, alum jar testing, and floc evaluation, must be completed prior to designing the system. ERD has the capability to complete these services as well as fabricate, test and install the alum stormwater treatment system in LaPorte, Indiana for approximately $100,000.

This letter serves as a summary of the attached Alum Stormwater Treatment Evaluation for Clear Lake which includes calculations and supporting information.

Sincerely,

Jeffrey L. Herr, P.E.
Vice President - Engineering

JLH:shd
Enclosure: Evaluation
ERD Project No. 95-003



E R D ENVIRONMENTAL RESEARCH AND DESIGN, INC.	CLEAR LAKE ALUM STORMWATER TREATMENT SYSTEM LaPORTE, INDIANA	CONCEPTUAL DESIGN	PROJECT NO.	95-003
			FIGURE NO.	1
			SCALE	AS SHOWN
			DATE	JUNE 1995

95003.dwg

CLEAR LAKE
ALUM STORMWATER
TREATMENT EVALUATION

1. **Treatment Goal**: Reduce annual phosphorus loading to Clear Lake by 80% for the contributing area for the 48-inch RCP on the southwest corner of Clear Lake.

2. **Treatment Objectives**: Treat 90% of the runoff for common storm events discharging through the 48-inch RCP up to the 2-year return frequency. It is assumed that approximately 90% of the annual pollutant mass for the sub-basin area will be treated in this volume of runoff.

3. **Design Drainage Area:** 88 acres (Provided by Harza, see Appendix A)

4. **Hydrologic Parameters**: (Provided by Harza, see Appendix A)

   a.

Land Use	Area (ac)	% Impervious
Commercial	46	85
Industrial	41	72
Park	1	20
Total:	88	78

   b. Runoff/Rainfall Volume Ratio is approximately 0.55.

5. **Estimated Annual Runoff Volume**: (Provided by Harza, see Appendix A)

   a. Annual Precipitation = 47.7 in/yr, use 48 in/yr

   b. Average Runoff Volume = 48 in/yr x 0.55 = 26.4 in/yr
   = (26.4 in/yr) x (1 ft/12 in) x 88 ac = 194 ac-ft/yr

6. **Determination of Average and Peak Runoff Rates from Common Storm Events**: (Provided by Harza, see Appendix A)

   a. Peak Discharges: The peak discharge in the 48-inch RCP for common rain events apparently is limited by, or approximately equals, pipe capacity. Peak discharges = 100 to 130 ft^3/sec.

b. Average Discharge: The average discharge for common rain events is approximately 25-35 ft^3/sec.

The treatment objective, as stated, is to treat 90% of the runoff discharging through the 48-inch RCP for common storm events up to the 2-year return frequency. Therefore, the alum treatment equipment must be sized to treat up to 130 ft^3/sec of stormwater runoff while also treating much lesser discharges.

7. Detention Time Provided by Proposed Sediment Trap

Sediment Trap Volume Provided = 6.8 ac-ft (Provided by Harza, see Appendix B)

For a peak discharge = 130 ft^3/sec, Detention Time = V/Q =

$$\frac{6.8\ ac\text{-}ft}{130\ ft^3/\text{sec}} \ x\ \frac{43{,}560\ ft^2}{ac} \ x\ \frac{\text{min}}{60\ \text{sec}} - 38\ minutes$$

For a peak discharge = 100 ft^3/sec, Detention Time =

$$\frac{6.8\ ac\text{-}ft}{100\ ft^3/\text{sec}} \ x\ \frac{43{,}560\ ft^2}{ac} \ x\ \frac{\text{min}}{60\ \text{sec}} - 49\ minutes$$

For an average discharge = 30 ft^3/sec, Detention Time =

$$\frac{6.8\ ac\text{-}ft}{30\ ft^3/\text{sec}} \ x\ \frac{43{,}560\ ft^2}{ac} \ x\ \frac{\text{min}}{60\ \text{sec}} - 165\ minutes - 2.7\ hours$$

8. Determination of Required Alum Pumping Rates:

Since no laboratory testing was conducted in this phase, an alum dose must be assumed. All previous alum treatment projects completed have required doses of 10 to 20 mg/l (as Al_2O_3) to treat stormwater runoff. A dose of 15 mg/l (as Al_2O_3) will be used for the subsequent calculations. Laboratory testing is needed to determine the actual dose.

Based on a dose of 15 mg/l as Al_2O_3, alum feed rates for average and peak stormwater flow were calculated for each storm event as follows:

STORMWATER FLOW RATE (ft^3/sec)	ALUM FLOW RATE (gpm)
5	0.3
30	1.8
100	6.1
130	7.9

9. **Determination of Annual Alum Requirement:**

Per previous calculations, the total estimated stormwater runoff volume is 194 ac-ft.

At a dose of 15 mg/l, this equates to an annual alum requirement of 8,580 gallons, assuming that all runoff is treated by the alum injection system.

10. **Determination of Annual Alum Floc Deposition:**

Since no settling tests were to be completed during this phase, floc volumes will be estimated based on previous studies. Laboratory testing will be needed during final design to determine the characteristics of the floc and settleability.

Based on previous studies, wet volume floc deposition after a settling time of 30 days is approximately 0.20% of the treated stormwater flow at a 15 mg/l Al_2O_3 dose.

$$194\ ac\text{-}ft\ runoff\ x\ \frac{0.002\ ft^3\ floc}{ft^3\ runoff} - 0.39\ ac\text{-}ft - 128{,}000\ gallons$$

Assuming the alum floc were to remain in the sediment trap and the trap has a bottom area of approximately 1.0 ac.

Annual Floc Depth Accumulation =

$$\frac{0.39\ ac\text{-}ft}{1.0\ ac} - 0.39\ ft - 4.7\ inches$$

The alum floc could be pumped to the sanitary sewer or can be pumped onto a drying bed with subsequent solids disposal.

11. Alum System Requirements:

a. Alum Pump:

The selected pump must be capable of treating up to 130 cfs of runoff.

A dose of 15 mg/l alum equates to a maximum alum flow of 7.9 gpm.

If pump is variable speed with 15:1 range, it could pump from 0.53 to 7.9 gpm.

0.53 gpm alum corresponds to 8.7 cfs of runoff.

Since many of the storm events which occur are low intensity and short duration, discharges through the 48-inch RCP below 8.7 cfs will occur frequently.

Since most storm events will have a peak discharge $<<$ 130 ft^3/sec, it may be beneficial to reduce the peak discharge treated, thus reducing the lower end discharge treated.

For example, if the peak discharge treated = 50 ft^3/sec, the minimum discharge treated = 3.3 ft^3/sec. These discharges would require alum flows of 3.0 gal/min and 0.2 gal/min, respectively.

b. Alum Storage Requirements:

The annual alum volume required to treat 194 ac-ft of runoff at an alum dose of 15 mg/l (as Al_2O_3) is 8,580 gallons.

Based on four deliveries per year, each delivery would include approximately 2,148 gallons.

To provide for adequate storage for the design storm event, a minimum on-site alum storage tank volume of 2,500 gallons should be used. This would allow the tank to receive one delivery (2145 gallons) while still containing more than 355 gallons.

c. Runoff Flow Sensor:

The stormwater runoff flow must be accurately measured to properly pace the alum pump. Since the 48-inch RCP storm sewer is normally full, a velocity type meter can be used. The velocity times the flow area of the pipe provides the discharge flow rate. Two velocity sensors would be placed in the 48-inch RCP upstream of the lake. A 4-20 mA signal from the flow meter would control the alum pump.

d. Building:

An above-ground building to house all equipment and storage tanks is desirable.

A precast concrete building could be used to house the alum pump, stormwater meter, alum pump controls, alum tank, recirculation pump, blower, and buffer system (if needed). Based on experience, a building approximately 10 feet wide and 14 feet long would be required.

An above-ground building allows much easier equipment installation and maintenance, and is typically less expensive than a comparable underground installation.

e. pH Monitoring/Buffer System

When aluminum sulfate is added to stormwater, alkalinity is consumed, thus lowering the pH of the treated water. If insufficient alkalinity is available, the pH will continue to depress below acceptable values. Since no stormwater runoff has been collected and no jar testing performed at this site, the need for a pH buffer system is unknown. It appears Clear Lake is moderately buffered based on the 60 mg/l of alkalinity as $CaCO_3$ measured in the one lake sample collected.

The pH monitoring/buffer system involves continuously monitoring pH in the lake and adding buffer as needed to maintain acceptable pH levels. A pH controller, recirculation pump, buffer pump, buffer storage tank, and miscellaneous valves, piping and tubing are required. To be conservative, the cost of this system has been added to the Conceptual Opinion of Cost provided. Laboratory testing is needed to determine the need for buffering and, if necessary, the required doses.

f. Miscellaneous:

Other facility requirements include PVC piping, fittings, valves, alum meters, and mixing equipment.

12. Conceptual Opinion of Probable Construction Cost:

Environmental Research & Design, Inc. (ERD) has the capability to perform the required stormwater sampling, alum jar testing, floc evaluation, as well as construct and install the alum system. The total estimated cost to complete these tasks is $100,000. These same services were performed by ERD for the alum stormwater treatment system in King County, Washington.

13. **Operation and Maintenance**:

a. Procedures:

(1) Once in operation, the alum treatment system will require weekly visits by personnel to check system operation and tank alum level. Four (4) man-hours should be allowed per week or 208 man-hours per year. All equipment will be covered by a 1-year warranty.

b. Cost: Based on the preceding procedures, annual costs for each item can be estimated.

(1) Weekly Maintenance Visits

208 man-hours x $15.00/man-hour = $3120.00
(rate includes wages plus benefits)

(2) Incidental Repairs, Materials Replacement

Labor: 96 man-hours x $15.00/man-hour = $1440.00

Materials: $500.00

(3) Alum

8,580 gallons x $0.52/gallon = $4,462.00

(4) Total Annual Estimated O&M Cost: $9,522.00

APPENDICES

APPENDIX A

ANNUAL RUNOFF VOLUME,
PEAK AND AVERAGE DISCHARGE
RATE CALCULATIONS

Clear Lake, LaPorte, IN
ANNUAL RUNOFF VOLUME

Purpose: Estimate annual runoff volume.

References:
Harza, "Clear Lake Enhancement Project, Sediment Trap Improvement, Supporting Design Report," Chi., Oct. 1993, pp. D-4, -5.
Environmental Data Service, "Monthly Normals of Temperature, Precipitation, and Heating and Cooling Degree Days 1941-70," Clim. of US No. 81 (Indiana), Natl. Clim. Center, Asheville, NC, Aug. 1973.
SCS, "Urban Hydrology for Small Watersheds," TR 55, 2nd ed., Wash., DC, June 1986, p. 2-5.
B.R. Urbonas and L.A. Roesner, "Hydrologic Design for Urban Drainage and Flood Control," Handbook of Hydrology, McGraw-Hill, NYC, pp. 28.1-.2.
USGS, "Water Resources Data, Indiana, Water Year 1984," WDR IN-84-1, Indianapolis, 1985, pp. 30, 186, 187, 211.

Data: DA = 88 ac (Harza)
Normal annual precipitation = 47.7 in/yr (EDS)

Method: Annual precipitation x rainfall-runoff coefficient

Procedure:

Land Use	Area, ac (Harza)	% Impervious (SCS)	A x I
Commercial	46	85	3910
Industrial	41	72	2952
Park	1	20	20
	-----	-----	-----
	88		6882
Weighted		78	(insensitive to park % imperviousness)

Runoff/rainfall volumes ratio ~ 0.55 (Urbonas, NURP graph)

Average runoff volume = 48" x 0.55 =	26	in/yr
/12 =	2.2	ft/yr
x 88 ac =	194	AF/yr
x 0.326 =	63	mil. gal./yr

Comparison to USGS streamgage runoffs, more pervious -

No.	Stream, Gage	Drainage Area, mi2 Total	Contrib.	Average RO, in/yr Total A	Contrib. A
4095300	Trail Cr. at Michigan City	54.1	54.1	18.22	18
4096100	Galena R. nr. LaPorte	17.2	14.9	20.13	23
5515400	Kinsbury Cr. nr. LaPorte	7.08	3.01	8.08	19

Thus, Clear Lake value of 26 in/yr reasonable

Result: Average annual runoff approximately 63 million gal.

NLS 4-19-95

Clear Lake, LaPorte, IN
BASEFLOW

Purpose:	Estimate annual baseflow volume (if any)
Data:	Not known if any baseflow Average annual runoff estimated as 63 mil. gal.
Method:	Judgment
Procedure:	Guess 10 % of average runoff, = 0.1 x 63 = 6 mil. gal./yr
Result:	6 mil. gal./yr guestimate

Clear Lake, LaPorte, IN
STORMWATER DISCHARGES

Purpose: Estimate range of peak and average stormwater discharges for common rain events.

Data: Pipe capacity about 130 cfs (WPM 3-95)
A = 88 ac (Harza)
Tc ~ 11 min. (Harza)
Weighted rational-formula C = 0.76 (Harza) for overland runoff

References:
Harza, "Clear Lake Enhancement Project, Sediment Trap Improvement, Supporting Design Report," Chi., Oct. 1993, pp. D-4, -5.
W.P. Moore, "IDNR Comments on Clear Lake Report," memo, Harza, Chi., Mar. 28, 1995.
F.A. Huff and J.R. Angel, "Rainfall Frequency Atlas of the Midwest," Bul. 71, Midwestern Climate Center, Champaign, 1992, pp. 6, 54.

Method: Estimate flood peaks for common storms, limit to pipe capacity.
Rational formula

Procedure: Q = CIA
C = 0.76 (Harza)
A = 88 ac (Harza)
Q = 0.76 x 88 x I= 67 x I
Tc ~ 11 min (Harza)

Bulletin 71 -

Dur., min.	Depth, % 24-hr	/60-min=	Depth, % 1-hr
60	47		100
15	27		57
10	21		45
11	22	by interp.	47

Partial-duration 24-hr depths

RI, months	% of 2-Yr Depth
12	83
6	67
4	58
3	53
2	46

Partial-duration 2-yr 1-hr point depth = 1.35 in.

Thus, 2-yr 11-min. depth = 1.35" x 47 % = 0.63 in.

RI, months	Depth, % 2-Yr	Depth, in.	I, in/hr	Q=CIA, cfs	Pipe Q, cfs
24	100	0.63	3.5	231	130
12	83	0.53	2.9	192	130
6	67	0.43	2.3	155	130

4	58	0.37	2.0	134	130
3	53	0.34	1.8	123	123
2	46	0.29	1.6	106	106

Result: Peak discharge for common rain events apparently is limited by or approximately equals pipe capacity. Peaks approximately 100-130 cfs.

No storm hydrographs. Thus, estimate average based on shape of SCS curvilinear dimensionless hydrograph:

Ref. SCS, NEH4, p. 16.4 -

Hr	Q/Qp	Avg	dT, hr	Avg x dT
0	0			
	0.03			
	0.1			
	0.19			
	0.31			
	0.47			
	0.66			
	0.82			
	0.93			
	0.99			
	1			
	0.99			
	0.93			
	0.86			
	0.78			
	0.68			
	0.56			
	0.46			
	0.39			
	0.33			
2	0.28	0.56	2	1.12
2	0.28			
	0.207			
	0.147			
	0.107			
	0.077			
	0.055			
	0.04			
	0.029			
	0.021			
	0.015			
4	0.011	0.089909	2	0.179818
4	0.011			
	0.005			
5	0	0.005333	1	0.005333
				--------
0 to 5				1.305152
Weighted average =		0.26		

Rl, mon	Peak,cfs	x 0.26 =	Ave.,cfs
4	134		35
3	123		32
2	106		28

Result: Average flow from commons storms approximately 25-35 cfs.

Attachment 2

E R D ENVIRONMENTAL RESEARCH & DESIGN, INC.

WATER QUALITY ENGINEERING
3419 TRENTWOOD BOULEVARD ■ SUITE 101 ■ ORLANDO, FLORIDA 32812
TELEPHONE: (407) 855-9465 FAX: (407) 826-0419

June 28, 1995

Mr. David B. Pott
Harza Consulting Engineers and Scientists
Sears Tower
233 South Wacker Drive
Chicago, IL 60606-6392

RE: Clear Lake - LaPorte, Indiana - Alum Stormwater Treatment System

Dear Mr. Pott:

As you requested, Environmental Research & Design, Inc. (ERD) has prepared a Scope of Services and Fee Summary for the Preliminary Design, Final Design, Construction, and Operation Phases for the alum stormwater treatment system to serve one pipe discharging to Clear Lake. As we discussed during our telephone conversation, it would be advisable to perform a biological survey of Clear Lake. The initial survey results can be compared to future biological surveys which can be conducted following operation of the alum stormwater treatment system. Alum stormwater treatment systems typically provide a finished water with a dissolved aluminum concentration less than 87 μg/l. The U.S. Environmental Protection Agency has recommended this value for dissolved aluminum to protect all freshwater species in the United States.

Please give me a call if you have any questions or comments regarding the enclosed documents. We would be pleased to provide the outlined services and are prepared to begin work immediately upon authorization.

Sincerely,

Jeffrey L. Herr, P.E.
Vice President - Engineering

JLH:shd

Enclosures: Scope of Services/Fee Schedule

Job No. 95-003

CLEAR LAKE
ALUM STORMWATER TREATMENT SYSTEM

WORK TASK BREAKDOWN

I. Preliminary Design Phase
-- Page Two --

TASK	COST ($)
II. LABORATORY EXPENSES	
A. Laboratory Analysis: A total of 3 stormwater samples will be collected and tested. For each field sample collected, there will be 6 laboratory samples including raw, settled, 10 mg/l dose, 15 mg/l dose, 20 mg/l dose and 25 mg/l dose.	
3 field tests x 6 samples/test x $200/sample	$3,600.00
Parameters include:	
1. pH; 2. Conductivity; 3. Alkalinity; 4. NH_3-N; 5. NO_3-N; 6. Organic N; 7. Total N; 8. Ortho-P; 9. Total P; 10. Turbidity; 11. Diss. Aluminum; 12. Total Copper; 13. Diss. Zinc; 14. Total Iron; 15. Hardness	
TOTAL LABORATORY EXPENSES:	**$3,600.00**
III. REIMBURSABLE EXPENSES	
A. Plotting — 4 plots @ $15/plot	60.00
B. Printing — 25 prints @ $1.00/print	25.00
C. Copies — 300 copies @ $0.10/copy	30.00
D. Travel — 2 meetings @ $1,000/each	2,000.00
E. Special Deliveries — 4 @ $25.00/delivery	100.00
TOTAL REIMBURSABLES:	**$ 2,215.00**
PRELIMINARY DESIGN PHASE SUB-TOTAL:	**$15,675.00**

CLEAR LAKE
ALUM STORMWATER TREATMENT SYSTEM

WORK TASK BREAKDOWN

II. Final Design Phase

I. LABOR		MAN-HOURS*			COST ($)
	TASK	PM	PE	T	
A.	Prepare 60% plans for the alum treatment system	4	10	16	
B.	Prepare 60% Opinion of Probable Construction Cost	--	2	--	
C.	Submit 3 sets of 60% documents for review and comment	--	1	--	
D.	Based on 60% comments, prepare 100% plans for the alum system	3	8	16	
E.	Prepare 100% Opinion of Probable Construction Cost	--	1	--	
F.	Submit 6 sets of 100% documents for review and comment	--	1	--	
	TOTAL LABOR:	**7**	**23**	**32**	**$ 3,610.00**

II.	**REIMBURSABLE EXPENSES**		
A.	Plotting	12 plots @ $15/plot	$ 180.00
B.	Printing	90 prints @ $1.00/print	90.00
C.	Copies	400 copies @ $0.10/copy	40.00
D.	Special Deliveries	4 @ $25.00/delivery	100.00
		TOTAL REIMBURSABLES:	**$ 410.00**
		FINAL DESIGN PHASE SUB-TOTAL:	**$ 4,020.00**

*LEGEND:
- PM: Project Manager ($80/hour)
- PE: Project Engineer ($70/hour)
- T: Technician ($45/hour)

CLEAR LAKE
ALUM STORMWATER TREATMENT SYSTEM

SCHEDULE

I. Preliminary Design Phase

A. 120 days from Notice to Proceed at Start-up Meeting

II. Final Design Phase

A. 60% Submittal: 21 days from Preliminary Design Phase Progress Meeting

B. 90% Submittal: 14 days after receiving 60% review comments

C. 100% Submittal: 14 days from receipt of 90% comments

III. System Fabrication, Installation and Start-Up Phase

A. 180 days from Final Design Phase design completion meeting*

IV. Operation Phase

A. 365 days from completion of system training

* May vary due to availability of system components